

**CLAIMS**

WHAT IS CLAIMED IS:

1. A process of extracting carotenoids from a source of fruit or vegetable processing waste comprising the steps of:  
admixing the source, a first organic solvent and a surfactant to form a slurry, whereby surface tension in tissue cell structure of the source is decreased, enhancing penetration of the surfactant into the tissue cell structure so that the carotenoids and the surfactant may form a combination;  
treating the slurry with a second organic solvent which solubilizes the combination;  
separating the treated slurry into a liquid fraction and a solid fraction;  
and  
separating a first portion from the liquid fraction, the first portion including a solution of the second organic solvent and the combination.
2. The process as recited in claim 1, wherein the first organic solvent is an alcohol.
3. The process as recited in claim 1, wherein the first organic solvent is selected from the group consisting of ethanol, methanol, n-propanol, i-propanol, n-butanol, i-butanol, s-butanol, n-amyl alcohol, i-amyl alcohol, cyclohexanol, n-octanol, ethanediol, and 1, 2-propanediol.

4. The process as recited in claim 1, wherein approximately 50-500 milliliters of first organic solvent is admixed for each kilogram of source.
5. The process as recited in claim 1, wherein the surfactant is a non-ionic surfactant.
6. The process as recited in claim 1, wherein the surfactant is a linear surfactant.
7. The process as recited in claim 1, wherein the surfactant is a linear alkyl ethoxylate.
8. The process as recited in claim 1, wherein approximately 0.1-10 milliliters of surfactant is admixed for each kilogram of source.
9. The process as recited in claim 1, wherein approximately 2 grams of surfactant is admixed for each kilogram of source.
10. The process as recited in claim 1, wherein the second organic solvent is a polar organic solvent.
11. The process as recited in claim 1, wherein the second organic solvent is non-miscible in water.
12. The process as recited in claim 1, wherein the liquid fraction is separated from the treated slurry by mechanical means.
13. The process as recited in claim 1, further including the step of mincing the source prior to the admixing step.
14. The process as recited in claim 1, further including the step of macerating the source prior to the admixing step.
15. The process as recited in claim 1, wherein the source is a byproduct of a wastewater treatment process.

16. The process as recited in claim 1, wherein the source is selected from the group consisting of a fruit and a vegetable.
17. The process as recited in claim 1, wherein the carotenoids present in the first portion are approximately at least 95% trans and approximately less than 5% cis.
18. The process as recited in claim 1, wherein the carotenoids present in the first portion are at a concentration of approximately at least 0.44 milligrams/milliliter.
19. The process as recited in claim 1, wherein the carotenoids present in the first portion are stable at standard, increased or decreased temperatures and pressures, stable under ultraviolet light and resistant to oxidation.
20. The process as recited in claim 1, further including the step of collecting the carotenoids from the first portion.
21. The process as recited in claim 20, wherein collecting carotenoids from the first portion includes the steps of:
  - 5 concentrating the carotenoids present in the first portion to a desired level;
  - treating the concentrated first portion with a mixture to precipitate the carotenoids in crystalline form; and
  - separating the crystalline carotenoids from the treated first portion.
- 10 22. The process as recited in claim 21, wherein the step of concentrating is performed at a low temperature.
23. The process as recited in claim 22, wherein the low temperature is approximately less than 51°C.

24. The process as recited in claim 21, wherein the desired level is  
15 approximately greater than 0.44 milligrams/milliliter of  
carotenoids.
25. The process as recited in claim 21, wherein the mixture includes  
ethanol and citric acid.
26. The process as recited in claim 25, wherein the citric acid is trisodium  
20 citrate.
27. The process as recited in claim 21, wherein the mixture includes  
approximately 100 milliliters of ethanol and approximately 1  
milligram of citric acid for each 10 milliliters of concentrated first  
portion.
- 25 28. The process as recited in claim 21, further including the step of  
adjusting a temperature of the concentrated first portion during  
the treating step.
29. The process as recited in claim 21, wherein the concentrated first  
portion is maintained at approximately 47-50°C during the step of  
30 treating the concentrated first portion.
30. The process as recited in claim 21, wherein the crystalline carotenoids  
are separated from the treated first portion by mechanical means.
31. The process as recited in claim 21, further including the step of  
alternately washing the crystalline carotenoids with ethanol then  
35 distilled water.
32. The process as recited in claim 31, further including the step of  
storing the washed crystalline carotenoids in a closed vessel at a  
cool temperature.

33. The process as recited in claim 1, wherein the carotenoids are present  
in the first portion in mole ratio to the surfactant approximately at  
1.6-2.2:1.
34. The process as recited in claim 1, wherein the carotenoids are present  
5 in the first portion at a yield of approximately at least 32  
milligrams/kilogram.

35. A process for extracting lycopene ( $\psi$ ,  $\psi$  – Carotene) from a source of  
tomato processing waste comprising the steps of:  
admixing the source, approximately 50-500 milliliters of ethanol for  
each kilogram of source and approximately 0.1-10 grams of  
5 surfactant for each kilogram of source, all to form a slurry;  
treating the slurry with carbon disulfide;  
separating the treated slurry into a liquid fraction and a solid fraction;  
and  
separating a first portion from the liquid fraction, the first portion  
10 including a solution of carbon disulfide, surfactant and lycopene.
36. The process as recited in claim 35, wherein the source is selected from  
the group consisting of tomatoes, rotted tomatoes, damaged  
tomatoes, tomato vines, tomato peels, rejected tomatoes,  
concentrated, high pH tomato peel, dry pumice and byproduct of a  
5 wastewater process.
37. The process as recited in claim 36, wherein each of the tomatoes,  
rotted tomatoes, damaged tomatoes, tomato vines, tomato peels  
concentrated high pH tomato peels and rejected tomatoes are  
minced prior to the admixing step.
38. The process as recited in claim 36, wherein the dry pumice is  
macerated prior to the admixing step.
39. The process as recited in claim 38, wherein water is added to the dry  
pumice in a ratio of water to dry pumice of 3:1.

40. The process as recited in claim 37, wherein water is added to the minced tomato vines prior to the admixing step in a ratio of water to minced tomato vines of 2:1.
41. The process as recited in claim 35, wherein the surfactant is a non-ionic surfactant.
42. The process as recited in claim 35, wherein the surfactant is a linear alkyl ethoxylate.
43. The process as recited in claim 35, wherein the solid fraction is separated from the liquid fraction by a mechanical means.
44. The process as recited in claim 35, wherein the first portion is separated from the liquid fraction by a separation funnel.
45. The process as recited in claim 35, wherein the lycopene collected from the first portion is approximately at least 95% trans and approximately less than 5% cis.
46. The process as recited in claim 35, wherein the lycopene is present in the first portion in mole ratio of the lycopene to the surfactant at 1.6-2.2:1.
47. The process as recited in claim 35, further including the step of collecting the lycopene from the first portion.
48. The process as recited in claim 47, wherein collecting lycopene from the first portion includes the steps of:  
concentrating the lycopene present in the first portion to a desired level;  
treating the concentrated first portion with a mixture to precipitate the lycopene in crystalline form; and

separating the crystalline lycopene from the treated first portion.

49. The process as recited in claim 48, wherein the step of concentrating is performed at a low temperature.
50. The process as recited in claim 49, wherein the low temperature is approximately less than 51°C.
51. The process as recited in claim 48, which the desired level is approximately greater than 0.44 milligrams/milliliter of lycopene.
52. The process as recited in claim 48, wherein the mixture includes ethanol and citric acid.
53. The process as recited in claim 52, wherein the citric acid is trisodium citrate.
54. The process as recited in claim 48, wherein the mixture includes approximately 100 milliliters of ethanol and approximately 1 milligram of citric acid for each 10 milliliters of concentrated first portion.
55. The process as recited in claim 48, further including the step of adjusting a temperature of the concentrated first portion during the treating step.
56. The process as recited in claim 48, wherein the concentrated first portion is maintained at approximately 47-50°C during the step of treating the concentrated first portion.
57. The process as recited in claim 48, wherein the crystalline lycopene is separated from the treated first portion by mechanical means.



58. The process as recited in claim 48, further including the steps of  
alternately washing the crystalline lycopene with ethanol then  
distilled water.
59. The process as recited in claim 58, further including the step of  
storing the washed crystalline lycopene in a closed vessel at a cool  
temperature.
60. The process as recited in claim 35, wherein the lycopene is present in  
the first portion is at a concentration of approximately at least 0.44  
milligrams/milliliter.
61. The process as recited in claim 35, wherein the lycopene is present in  
the first portion at a yield of approximately at least 32  
milligrams/kilogram.

62. A process for extracting zeaxanthin ( $\beta$   $\beta$  - Carotene - 3, 3' - diol) and lutein ( $\beta$ , $\epsilon$  - Carotene - 3, 3' - diol) from leafy greens comprising the steps of:
- mincing the leafy greens;
- 5 macerating the leafy greens with approximately 500 grams of distilled water for each kilogram of leafy greens;
- admixing the macerated leafy greens, approximately 50-500 grams of ethanol for each kilogram of leafy greens and approximately 0.1-10 grams of surfactant for each kilogram of leafy greens, all to form a
- 10 slurry;
- treating the slurry with carbon disulfide;
- separating the treated slurry into a liquid fraction and a solid fraction;
- and
- separating a first portion from the liquid fraction, the first portion
- 15 including a solution of the carbon disulfide, surfactant, zeaxanthin and lutein.
63. The process as recited in claim 62, wherein the surfactant is a non-ionic surfactant.
64. The process as recited in claim 63, wherein the surfactant is a linear alkyl ethoxylate.
65. The process as recited in claim 62, wherein the solid fraction is separated from the liquid fraction by a mechanical means.
66. The process as recited in claim 62, wherein the first portion is separated from the liquid fraction by a separation funnel.

67. The process as recited in claim 62, wherein the zeaxanthin and lutein are present the first portion in mole ratio of the zeaxanthin and lutein to the surfactant at 1.6 – 2.2:1.
68. The process as recited in claim 62, wherein the zeaxanthin and lutein collected from the first portion is approximately at least 95% trans and approximately less than 5% cis.
69. The process as recited in claim 62, further including the step of collecting the zeaxanthin and lutein from the first portion.
70. The process as recited in claim 69, wherein collecting zeaxanthin and lutein from the first portion includes the steps of:  
concentrating the zeaxanthin and lutein present in the first portion to a desired level;  
treating the concentrated first portion with a mixture to precipitate the zeaxanthin and lutein in crystalline form; and  
separating the crystalline zeaxanthin and lutein from the treated first portion.
71. The process as recited in claim 70, wherein the step of concentrating is performed at a low temperature.
72. The process as recited in claim 71, wherein the low temperature is approximately less than 51°C.
73. The process as recited in claim 70, which the desired level is approximately greater than 0.44 milligrams/milliliter of zeaxanthin and lutein.
74. The process as recited in claim 70, wherein the mixture includes ethanol and citric acid.

75. The process as recited in claim 74, wherein the citric acid is trisodium citrate.
76. The process as recited in claim 70, wherein the mixture includes approximately 100 milliliters of ethanol and approximately 1 milligram of citric acid for every 10 milliliters of concentrated first portion.
77. The process as recited in claim 70, further including the step of adjusting a temperature of the concentrated first portion during the treating step.
78. The process as recited in claim 70, wherein the concentrated first portion is maintained at approximately 47-50°C during the step of treating the concentrated first portion.
79. The process as recited in claim 70, wherein the crystalline zeaxanthin and lutein are separated from the treated first portion by mechanical means.
80. The process as recited in claim 70, further including the step of alternately washing the crystalline zeaxanthin and lutein with ethanol then distilled water.
81. The process as recited in claim 80, further including the step of storing the washed crystalline zeaxanthin and lutein in a closed vessel at a cool temperature.
82. The process as recited in claim 62, wherein the zeaxanthin and lutein are present in the first portion is at a concentration of approximately at least 0.44 milligrams/milliliter.

83. The process as recited in claim 62, wherein the zeaxanthin and lutein are present in the first portion at a yield of approximately at least 32 milligrams/kilogram.

84. A process for extracting beta-carotene ( $\beta$   $\beta$  - Carotene) from a source of carrot processing waste comprising the steps of:  
admixing the source, approximately 50-500 milliliters of ethanol for each kilogram of source and approximately 0.1-10 grams of surfactant for each kilogram of source, all to form a slurry;  
treating the slurry with carbon disulfide;  
separating the treated slurry into a liquid fraction and a solid fraction;  
and  
separating a first portion from the liquid fraction, the first portion including a solution of carbon disulfide, surfactant and beta-carotene.
85. The process as recited in claim 84, wherein the source is selected from the group consisting of carrots, rotted carrots, damaged carrots, carrot vines, carrot peels, rejected carrots, concentrated, high pH carrot peel and byproduct of a wastewater process.
86. The process as recited in claim 85, wherein each of the carrots, rotted carrots, damaged carrots, carrot vines, carrot peels, concentrated high pH carrot peels and rejected carrots are minced prior to the admixing step.
87. The process as recited in claim 86, wherein water is added to the minced carrot vines prior to the admixing step in a ratio of water to minced tomato vines at 2:1.
88. The process as recited in claim 84, wherein the surfactant is a non-ionic surfactant.

89. The process as recited in claim 84, wherein the surfactant is a linear alkyl ethoxylate.
90. The process as recited in claim 84, wherein the solid fraction is separated from the liquid fraction by a mechanical means.
91. The process as recited in claim 84, wherein the first portion is separated from the liquid fraction by a separation funnel.
92. The process as recited in claim 84, wherein the beta-carotene collected from the first portion is approximately at least 95% trans and approximately less than 5% cis.
93. The process as recited in claim 84, wherein the beta-carotene is present in the first portion in mole ratio of the beta-carotene to the surfactant at 1.6-2.2:1.
94. The process as recited in claim 84, further including the step of collecting the beta-carotene from the first portion.
95. The process as recited in claim 94, wherein collecting beta-carotene from the first portion includes the steps of:  
concentrating the beta-carotene present in the first portion to a desired level;  
treating the concentrated first portion with a mixture to precipitate the beta-carotene in crystalline form; and  
separating the crystalline beta-carotene from the treated first portion.
96. The process as recited in claim 95, wherein the step of concentrating is performed at a low temperature.
97. The process as recited in claim 96, wherein the low temperature is approximately less than 51°C.

98. The process as recited in claim 95, which the desired level is  
approximately greater than 0.42 milligrams/milliliter of beta-  
carotene.
99. The process as recited in claim 95, wherein the mixture includes  
ethanol and citric acid.
100. The process as recited in claim 99, wherein the citric acid is trisodium  
citrate.
101. The process as recited in claim 95, wherein the mixture includes  
approximately 100 milliliters of ethanol and approximately 1  
milligram of citric acid for each 10 milliliters of concentrated first  
portion.
102. The process as recited in claim 95, further including the step of  
adjusting a temperature of the concentrated first portion during  
the treating step.
103. The process as recited in claim 95, wherein the concentrated first  
portion is maintained at approximately 47-50°C during the step of  
treating the concentrated first portion.
104. The process as recited in claim 95, wherein the crystalline beta-  
carotene is separated from the treated first portion by mechanical  
means.
105. The process as recited in claim 95, further including the step of  
alternately washing the crystalline beta-carotene with ethanol then  
distilled water.



106. The process as recited in claim 105, further including the step of  
storing the washed crystalline beta-carotene in a closed vessel at a  
cool temperature.
107. The process as recited in claim 84, wherein the beta-carotene is  
present in the first portion is at a concentration of approximately at  
least 0.42 milligrams/milliliter.
108. The process as recited in claim 84, wherein the beta-carotene is  
present in the first portion at a yield of approximately at least 32  
milligrams/kilogram.

109. A composition resulting from a process of extracting carotenoids from  
a source of fruit or vegetable processing waste comprising:  
a solution including,  
a combination composed of a surfactant and the carotenoids; and  
an organic solvent, wherein the combination is solubilized in the  
organic solvent at a concentration of approximately at least 0.44  
milligrams/milliliter.
110. The composition as recited in claim 109, wherein the surfactant is a  
non-ionic surfactant.
111. The composition as recited in claim 109, wherein the surfactant is a  
linear alkyl ethoxylate.
112. The composition as recited in claim 109, wherein the organic solvent  
is carbon disulfide.
113. The composition as recited in claim 109, further including oil from the  
source present in the solution at approximately less than 75  
percent by weight.
114. The composition as recited in claim 109, further including oil from the  
source present in the solution at approximately less than 5 percent  
by weight and the carotenoids present in the solution at  
approximately at least 90 percent by weight.
115. The composition as recited in claim 109, wherein the carotenoids are  
present in the solution at approximately more than 10 percent by  
weight.

116. The composition as recited in claim 109, wherein the solution is shelf stable over a wide temperature range and not affected by oxidation or ultraviolet light degradation.
117. The process as recited in claim 109, wherein the carotenoids are present in the solution at a yield of approximately at least 32 milligrams/kilogram